



August 29, 2016

Mr. Jason Senn, P.E.
Montana Fish, Wildlife & Parks
P.O. Box 200701
Helena, MT 59620-0701

RE: Widow Coulee Road Geotechnical Investigation

Dear Mr. Senn;

Widow Coulee Road in Choteau County provides passage to the Widow Coulee Fishing Access Site (FAS) on the Missouri River. Some portions of Widow Coulee Road are relatively steep, having gradients up to 21 percent. Montana Fish, Wildlife and Parks (FWP) is designing a modified Widow Coulee Road alignment to reduce the road gradient. Pioneer Technical Services, Inc. (Pioneer) performed a limited geotechnical investigation to determine depth to bedrock along the proposed road alignment.

INVESTIGATION

Three boreholes (BH-01 through BH-03) were drilled on August 17, 2016. The drilling work was performed by Boland Drilling of Great Falls, Montana under subcontract to Pioneer. The boreholes were advanced with a CME-55 truck-mount drill rig using hollow stem augers. The approximate location of each borehole is shown on Figure 1. FWP requested each borehole be drilled to a 20-foot depth.

Standard penetration tests (SPT) were performed at 5-foot intervals, in general accordance to ASTM D1586, using a 2-inch outside diameter, 2-foot long, steel standard split spoon sampler. Field measured blow counts were used to establish the relative density of granular soils and the consistency of cohesive soils. Samples were collected from each SPT interval and were field classified in general accordance with the Visual-Manual Procedure (ASTM D2488). Laboratory testing of soils was not included in the scope of work.

SOIL LITHOLOGY

The list below provides a summary of the soil profile from each borehole. Attachment A contains detailed borehole logs. Attachment B includes photos of the investigation and site.

- BH-01:** Silty clay surficial soils underlain by fat clay to bottom of borehole at 21.5-foot depth.
- BH-02:** Silty clay surficial soils underlain by fat clay to bottom of borehole at 21.5-foot depth.

BH-03: Silty clay surficial soils underlain by alternating layers of silt, sand, and clay to depth of 17 feet. Highly weathered siltstone was logged from 17 feet to the bottom of the borehole at 19.8 feet. Note: auger refusal was encountered at a depth of 18.3 feet.

The soil lithologies submitted in this letter are based upon visual classifications from samples obtained within each of the three investigation boreholes. Often, variations occur between boreholes, the nature and extent of which do not become evident until additional exploration or construction is conducted.

USE OF REPORT

This report is for the exclusive use of FWP. In the absence of Pioneer's written approval, Pioneer makes no representation and assumes no responsibility to other parties regarding this report. The data, analyses, and recommendations may not be appropriate for other purposes. Other parties contemplating other structures or purposes should contact Pioneer. .

Services performed by Pioneer Technical Services personnel for this project have been conducted with the level of care and skill ordinarily exercised by members of the profession currently practicing in this area under similar budget and time restraints. No warranty, expressed or implied, is made.

Thank you for the opportunity to work on your project. If you have any questions regarding these borehole logs please contact Mike Browne at 406-443-6053.

Sincerely,
PIONEER TECHNICAL SERVICES, INC.

Michael Browne, P.E.
Geotechnical Engineer

Attachments:

- A. Borehole Logs
- B. Photo Log

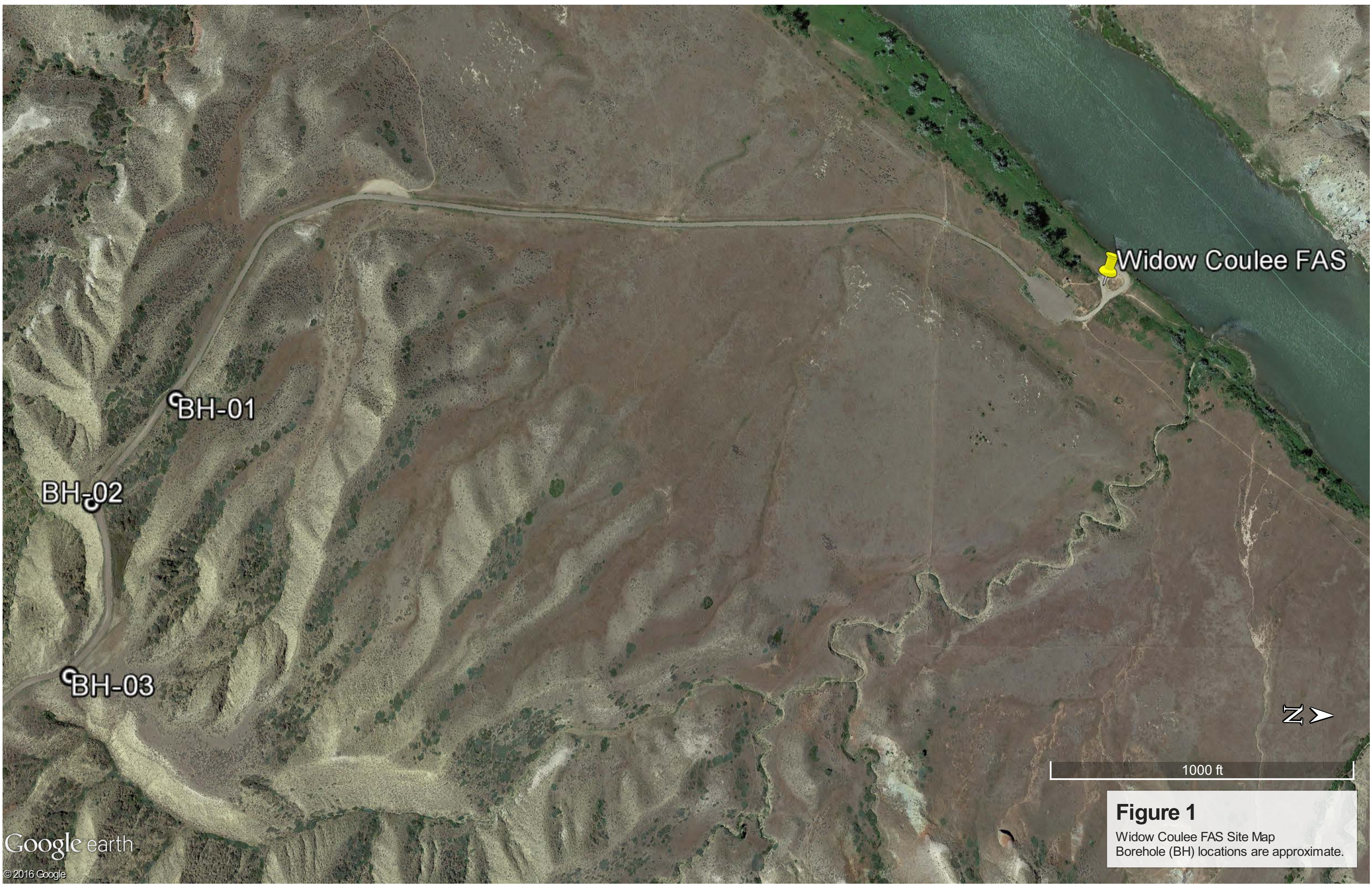












Figure 1
Widow Coulee FAS Site Map
Borehole (BH) locations are approximate.



Attachment A – Borehole Logs

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS: 	Split Spoon - 1-3/8" I.D., 2" O.D., unless otherwise noted	CA: 	Casing Advancer
ST: 	Thin-Walled Tube - 2" O.D., unless otherwise noted	DA: 	Drill Auger
CB: 	California Sampler - 2" I.D., 2.5" O.D., unless otherwise noted	HA: 	Hand Auger
DB: 	Diamond Bit Coring - 4", NX, unless otherwise noted	RB: 	Rock Bit
BS: 	Bulk Sample or Auger Sample	GS: 	Grab Sample

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value". The field blow counts are reported for each 6-inch interval, or portion thereof if greater than 50 blows are required to advance the full 6-inch interval. For over-sized split spoon samplers, non-standard hammers, or non-standard drop heights, the field penetration values are reported on the bore log. The values must be corrected to obtain the N-value.

WL: Water Level	WS: While Sampling	NE: Not Encountered
WCI: Wet Cave in	WD:  While Drilling	
DCI: Dry Cave in	BCR: Before Casing Removal	
AB: After Boring	ACR:  After Casing Removal	

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

DESCRIPTIVE SOIL CLASSIFICATION: Soil classification is based on the Unified Soil Classification System, Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: gravel or sand. Cobbles and boulders are not part of the USCS system but are included, when present, as percentages. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; depending on their plasticity, they are described as clays or silts. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

CONSISTENCY OF FINE-GRAINED SOILS

<u>Unconfined Compressive Strength, Qu, psf</u>	<u>Standard Penetration or N-value (SS) Blows/Ft.</u>	<u>Consistency</u>
< 500	< 2	Very Soft
500 - 1,000	2 - 4	Soft
1,001 - 2,000	5 - 8	Medium Stiff
2,001 - 4,000	9 - 15	Stiff
4,001 - 8,000	16 - 30	Very Stiff
8,000 +	30 +	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

<u>Standard Penetration or N-value (SS) Blows/Ft.</u>	<u>California Barrel (CB) Blows/Ft.</u>	<u>Relative Density</u>
0 - 4	0 - 6	Very Loose
5 - 10	7 - 18	Loose
11 - 30	19 - 58	Medium Dense
31 - 50	59 - 98	Dense
50 +	99 +	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

<u>Descriptive Term(s) of other constituents</u>	<u>Percent of Dry Weight</u>
Trace	< 15
With	15 - 29
Modifier	> 30

USCS* GRAIN SIZE TERMINOLOGY

<u>Major Component of Sample</u>	<u>Particle Size</u>
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75 mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

*For AASHTO grain size the #4 sieve is replaced with the #10 sieve

RELATIVE PROPORTIONS OF FINES

<u>Descriptive Term(s) of other constituents</u>	<u>Percent of Dry Weight</u>
Trace	< 5
With	5 - 12
Modifiers	> 12

PLASTICITY DESCRIPTION

<u>Term</u>	<u>Plasticity Index</u>
Non-Plastic	0
Slightly	1 - 5
Low	6 - 10
Medium	11 - 20
High	21 - 40
Very Highly	> 40



GENERAL NOTES

Description of Rock Properties

WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

FIELD HARDNESS (for engineering description of rock not to be confused with Moh's scale for minerals)

Very Hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately Hard	Can be scratched with knife or pick. Gouges or grooves to 1/4 in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very Soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding and Foliation Spacing in Rock ^a

Spacing		Joints	Bedding/Foliation
Less than 2 in.		Very close	Very thin
2 in. - 1 ft.		Close	Thin
1 ft. - 3 ft.		Moderately close	Medium
3 ft.-10 ft.		Wide	Thick
More than 10 ft.		Very wide	Very thick

Rock Quality Designation (RQD) ^b		Joint Openness Descriptors	
ROD, as a percentage	Diagnostic description	Openness	Descriptor
Exceeding 90	Excellent	No Visible Separation	Tight
90 - 75	Good	Less than 1/32 in.	Slightly Open
74 - 50	Fair	1/32 to 1/8 in.	Moderately Open
49 - 25	Poor	1/8 to 3/8 in.	Open
Less than 25	Very poor	1/2 in. to 1 1/4 in.	Moderately Wide
		Greater than 1 1/4 in.	Wide

a. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

b. RQD (given as a percentage) = length of core in pieces 4 in. and longer/length of run.

References: American Society of Civil Engineers Manuals and Reports on Engineering Practice - No. 56, American Society of Civil Engineers, 1976.
 U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.
 AASHTO M145, 2010.



UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests ^A

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests ^A				Soil Classification		
				Group Symbol	Group Name ^B	
Coarse Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines	$Cu \geq 4$ and $1 \leq Cc \leq 3$	GW	Well-graded Gravel ^F	
			$Cu < \text{and/or } 1 > Cc > 3$	GP	Poorly graded gravel ^F	
		Gravels with Fines More than 12% fines	Fines classify as ML or MH	GM	Silty Gravel ^{F,G,H}	
			Fines classify as CL or CH	GC	Clayey Gravel ^{F,G,H}	
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines	$Cu \geq 6$ and $1 \leq Cc \leq 3$	SW	Well-graded Sand ^I	
			$Cu < 6$ and/or $1 > Cc > 3$	SP	Poorly graded Sand ^I	
		Sands with Fines More than 12% fines	Fines classify as ML or MH	SM	Silty Sand ^{G,H,I}	
			Fines classify as CL or CH	SC	Clayey Sand ^{G,H,I}	
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	$PI > 7$ and plots on or above "A" line	CL	Lean Clay ^{K,L,M}	
			$PI < 4$ or plots below "A" line	ML	Silt ^{K,L,M}	
		organic	Liquid limit - oven dried	< 0.75	OL	Organic Clay ^{K,L,M,N}
			Liquid limit - not dried		Organic Silt ^{K,L,M,Q}	
	Silts and Clays Liquid Limit 50 or more	inorganic	PI plots on or above "A" Line	CH	Fat Clay ^{K,L,M}	
			PI plots below "A" line	MH	Elastic Silt ^{K,L,M}	
		organic	Liquid limit - oven dried	< 0.75	OH	Organic Clay ^{K,L,M,P}
			Liquid limit - not dried		Organic Silt ^{K,L,M,Q}	
Highly organic soils	Primarily organic matter, dark in color, and organic odor			PT	Peat	

^A Based on the material passing the 3-in. (75-mm) sieve

^B If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

^C Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

^D Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

$$^E Cu = D_{60} / D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

^F If soil contains $\geq 15\%$ sand, add "with sand" to group name.

^G If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

^H If fines are organic, add "with organic fines" to group name.

^I If soil contains $\geq 15\%$ gravel, add "with gravel" to group name.

^J If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

^K If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

^L If soil contains $\geq 30\%$ plus No. 200, predominantly sand, add "sandy" to group name.

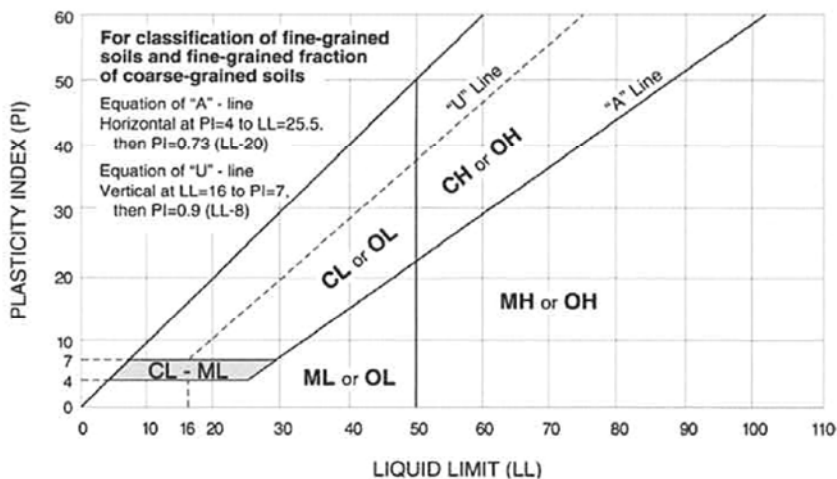
^M If soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

^N $PI \geq 4$ and plots on or above "A" line.

^O $PI < 4$ or plots below "A" line.

^P PI plots on or above "A" line.

^Q PI plots below "A" line.



201 E Broadway STE C
Helena, MT 59602
Phone: 406-457-8252
Fax: 406-442-1158

BOREHOLE LOG



Project Name: Widow Coulee FAS Road						Project Number:					
Borehole Location: Side of road, 20' north of centerline						Borehole Number: BH-01			Sheet <u>1</u> of <u>1</u>		
Drilling Equipment: CME 55				Hammer: Type: Safety		Driller: Boland			Logger: Browne		
Drilling Fluid: NA				Borehole Diameter (in): 6		Date Started: 8/17/2016			Date Finished: 08/17/2016		
Elevation and Datum: Ground: 2810.00 Casing:						Notes: N 47°37.210', W 111°01.813' Borehole coordinates from consumer grade GPS. Pocket Penetrometer (PP) in tons per square foot (tsf).					

DEPTH (feet)	OPERATION	PRESSURE (psi)	RATE (fph)	CORE PERCENT RECOVERY	ROCK QUALITY DESIGNATION (RQD)	SAMPLE	RECOVERY (%)	STANDARD PENETRATION TEST	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (feet)	REMARKS
0			90											Surficial Soils; Silty CLAY with Gravel (CL-ML); dry; brown; mild reaction to 10% HCl solution; medium plastic. Gravel particles are rounded.	1.0	
5														Fat CLAY with Sand (CH); damp; brown; stiff; mild reaction to 10% HCl solution; highly plastic.		
8			80				50	6/8/7						PP _{ave} =3.5 tsf		
10																
11			110				95	6/11/14						Fat CLAY (CH); trace fine Gravels; occasional Sand seams; very stiff; mild reaction to 10% HCl solution; highly plastic. Gravel particles are rounded.	10.0	
14														PP _{ave} >4.5 tsf		
16																
18			40				95	6/11/15						PP _{ave} >4.5 tsf		
20																
22																
24																
26																
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Operation Types: Auger Casing Advancer Core Barrel Drive Casing	Sampler Types: Split Spoon Shelby Bulk Sample Grab Sample	Penetrometer Vane Shear Special Samplers Testpit
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WATER LEVEL OBSERVATIONS			
While Drilling	<u> </u> ft	Upon Completion of Drilling	<u> </u> ft
Time After Drilling	<u> </u>		
Depth To Water (feet)	<u> </u>		
Remarks: Groundwater table was not encountered during drilling.			

MT_DOT WIDOW_COULEE-2016.GPJ PIONEER.GDT 8/23/16

201 E Broadway STE C
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BOREHOLE LOG



Project Name: Widow Coulee FAS Road						Project Number:					
Borehole Location: Road shoulder, 15' south of centerline						Borehole Number: BH-02			Sheet <u>1</u> of <u>1</u>		
Drilling Equipment: CME 55				Hammer: Type: Safety		Driller: Boland			Logger: Browne		
Drilling Fluid: NA				Borehole Diameter (in): 6		Date Started: 8/17/2016			Date Finished: 08/17/2016		
Elevation and Datum: Ground: 2925.00 Casing:						Notes: N 47°37.210', W 111°01.813' Borehole coordinates from consumer grade GPS. Pocket Penetrometer (PP) in tons per square foot (tsf).					

DEPTH (feet)	OPERATION	PRESSURE (psi)	RATE (fph)	CORE PERCENT RECOVERY	ROCK QUALITY DESIGNATION (RQD)	SAMPLE	RECOVERY (%)	STANDARD PENETRATION TEST	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (feet)	REMARKS
0			200											Surficial Soils; Silty CLAY with Gravel (CL-ML); dry; brown; mild reaction to 10% HCl solution; medium plastic. Gravel particles are rounded.	1.0	
5			360				55	1/3/3						Fat CLAY (CH) with trace fine Gravels; damp; brown; medium stiff; weak reaction to 10% HCl solution; highly plastic.		
10			160				100	2/4/5						Fat CLAY (CH) with trace fine Gravels; trace Coal; damp; brown; stiff; weak reaction to 10% HCl solution; highly plastic. Gravel particles are rounded.	10.0	
15			280				70	3/4/7						PP _{ave} =2.3 tsf Vertical Sand seam (1/16" thick) from 10.75 to 11.5 ft depth, white, fine-grained.		
20							100	3/6/7						PP _{ave} =2.8 tsf	21.5	

Operation Types: Auger Casing Advancer Core Barrel Drive Casing	Sampler Types: Split Spoon Shelby Bulk Sample Grab Sample	Penetrometer Vane Shear Special Samplers Testpit	WATER LEVEL OBSERVATIONS While Drilling <u> </u> ft Upon Completion of Drilling <u> </u> ft Time After Drilling <u> </u> Depth To Water (feet) <u> </u> Remarks: Groundwater table was not encountered during drilling.
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BOREHOLE LOG



Project Name: Widow Coulee FAS Road						Project Number:					
Borehole Location: Side of road, 23' east of centerline						Borehole Number: BH-03			Sheet <u>1</u> of <u>1</u>		
Drilling Equipment: CME 55				Hammer: Type: Safety		Driller: Boland			Logger: Browne		
Drilling Fluid: NA				Borehole Diameter (in): 6		Date Started: 8/17/2016			Date Finished: 08/17/2016		
Elevation and Datum: Ground: 3117.00 Casing:						Notes: N 47°37.160', W 111°01.591' Borehole coordinates from consumer grade GPS. Pocket Penetrometer (PP) in tons per square foot (tsf).					

DEPTH (feet)	DRILL				CORE PERCENT RECOVERY	ROCK QUALITY DESIGNATION (RQD)	SAMPLE	RECOVERY (%)	STANDARD PENETRATION TEST	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (feet)	REMARKS
	OPERATION	PRESSURE (psi)	RATE (fph)	SPT													
0			300												Surficial Soils; Silty CLAY with Gravel (CL-ML), occasional Cobbles; dry; brown; mild reaction to 10% HCl solution; medium plastic. Gravel particles are rounded.	1.0	
5															Sandy SILT (ML); occasional Sand seams; damp; brown; medium stiff; strong reaction to 10% HCl solution; non-plastic.		
6			280				60	1/2/3							Poorly Graded SAND with Silt (SP); fine-grained; damp; light brown; strong reaction to 10% HCl solution; non-plastic.	6.0	
10															Fat CLAY (CH); varved; damp; brown; stiff; strong reaction to 10% HCl solution; highly plastic.	9.0	
11			70				55	4/4/5							Poorly Graded SAND with Silt (SP); fine-grained; damp; light brown; strong reaction to 10% HCl solution; non-plastic.	11.8	
15															Sandy Lean CLAY (CL); damp; brown; very stiff; strong reaction to 10% HCl solution; medium plastic.	15.0	Soil to brittle for PP.
17			20				55	6/9/9							SILTSTONE; dry; weak field strength; iron staining; highly weathered.	17.0	Hard drilling at 17 ft depth.
18																	Auger refusal at 18.3 ft depth.
19																	
19.8																	

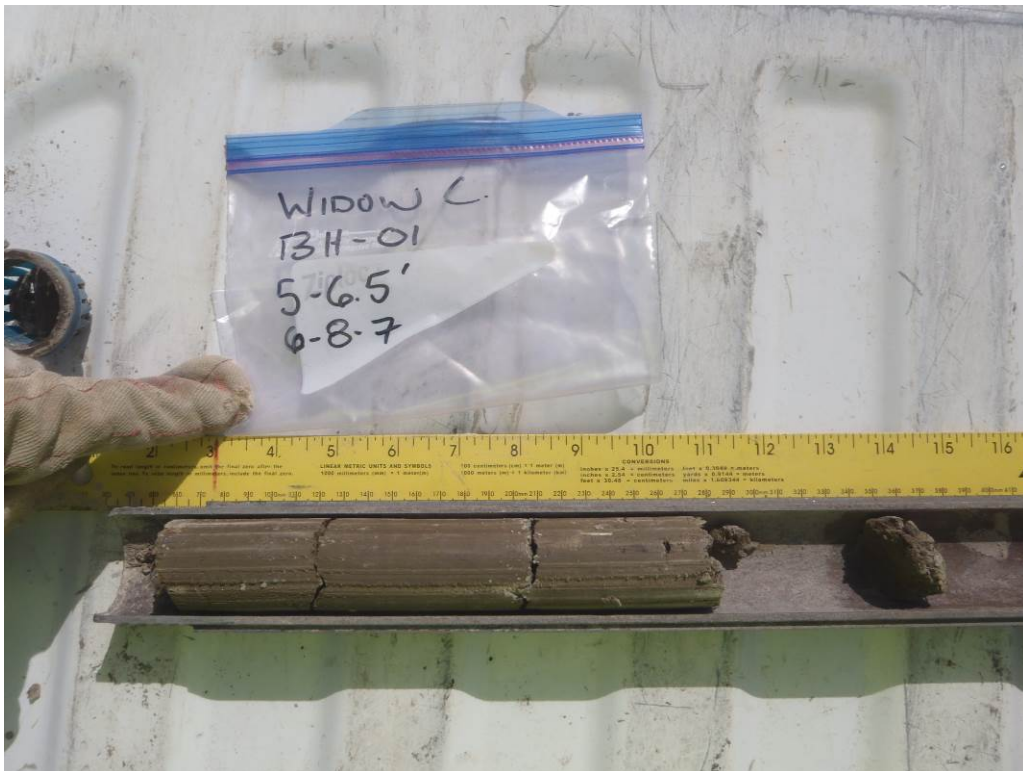
Operation Types: Auger Casing Advancer Core Barrel Drive Casing	Sampler Types: Split Spoon Shelby Bulk Sample Grab Sample	Penetrometer Vane Shear Special Samplers Testpit	WATER LEVEL OBSERVATIONS While Drilling <u> </u> ft Upon Completion of Drilling <u> </u> ft Time After Drilling <u> </u> Depth To Water (feet) <u> </u> Remarks: Groundwater table was not encountered during drilling.
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MT_DOT WIDOW_COULEE-2016.GPJ PIONEER.GDT 8/23/16

Attachment B – Photo Log



Picture #: 1 Description: BH-01, looking northwest.



Picture #: 2 Description: BH-01; 5-6.5 ft sample depth.



Picture #: 3

Description: BH-01; 10-11.5 ft sample depth.



Picture #: 4

Description: BH-01; 15-16.5 ft sample depth.



Picture #: 5 Description: BH-01; 20-21.5 ft sample depth.



Picture #: 6 Description: BH-02, looking northeast.



Picture #: 7 Description: BH-02; 5-6.5 ft sample depth.



Picture #: 8 Description: BH-02; 10-11.5 ft sample depth.



Picture #: 9

Description: BH-02; 15-16.5 ft sample depth.



Picture #: 10

Description: BH-02; 20-21.5 ft sample depth.



Picture #: 11 Description: BH-03, looking north.



Picture #: 12 Description: BH-03; 5-6.5 ft sample depth.



Picture #: 13

Description: BH-03; 10-11.5 ft sample depth.



Picture #: 14

Description: BH-03; 10-11.5 ft sample depth.



Picture #: 15

Description: BH-03; 15-16.5 ft sample depth.



Picture #: 16

Description: BH-03; 18.3-19.8 ft sample depth.